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## HEMIOPIA;

*Mechanism of its Causation on the Theory  
of TOTAL Decussation of the Optic*

*Nerve Fibres in the Optic Tract*

*at the Chiasma (Optic  
Commissure.)*

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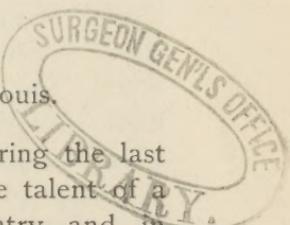


Art. VII.—Hemiopia.—Mechanism of its  
Causation on the Theory of TOTAL  
Decussation of the Optic Nerve Fibres  
in the Optic Tracts at the Chiasma,  
(Optic Commissure).

By WILLIAM DICKINSON, M. D., St. Louis.

IN the discussion of this subject, which, during the last score of years especially, has engaged the talent of a large number of investigators in this country and in Europe, I beg to premise that I assert no claim to original research, but have simply availed myself of the achievement of others; and, in as brief manner as is consistent with the importance which I attach to the subject, I shall present the results to which I have arrived, from a faithful perusal of the literature which they have furnished, and which has been accessible to me.

For the better elucidation of my subject, I briefly refer to the anatomy of the optic apparatus. The term "*optic nerves*" I shall employ exclusively to designate that portion of this apparatus extending from the optic commissure anteriorly to the globe; while that of the "*optic tract*" embraces all that portion extending from the commissure, posteriorly, to its multiple sources of origin in different parts of the brain. Systematic works on "*Anatomy*" teach that each optic *tract* derives its origin from the *Corpora Geniculata*, from the posterior and inferior aspect of the *Optic Thalamus*, and from the *optic thalamus itself*, and from the *Corpora Quadrigemina*. From these points of origin it proceeds forward and joins with its fellow in front of the *Tuber Cinereum*, to form the *optic commissure*; that, within the commissure, the *central fibres* of each tract cross each other to pass to



the opposite eye; while the *outer* fibres of each continue their course uninterruptedly to the eye of the *corresponding* side. This mode of crossing, of a portion of the optic nerve fibres, is termed *partial* or semi-decussation. According to this doctrine, the *nasal* half of each retina is supplied by the optic tract of the *opposite* side; while the *temporal* half receives its contingent from the tract of the *same* side. Fibres continued across the anterior border of the chiasma are described, connecting the *optic nerves* of the two sides, having no relation with the optic tracts. In respect to these, Gudden, of acknowledged high authority, states: "they cannot be demonstrated." Fibres corresponding to these are also described upon the inner margin of each optic tract, continued across from one to the other side of the brain, having no connection with the optic nerves. The same anatomist states: "these do exist, but they have no physiological relation to the nerves; on the contrary, they are wholly independent of them."

Thus divested of all collateral fibres, we have remaining, as the constituents of the optic commissure, fibres which *cross* each other, and fibres which do not cross each other; both together subsequently in their course, forming the optic nerve of each eye. Now, is this description true, or is it not? Does a *part* only of the fibres of each optic tract cross each other in the chiasma, or do *all* the fibres thus cross each other? If *all* the fibres cross each other, then the optic *nerve* proceeding to each eye is the continuation through the chiasma solely of the optic nerve fibres of the optic *tract* of the *other* side; if they do not, then the former description is correct, viz: that each optic nerve is composed of both the crossed fibres and the lateral fibres. Our inquiry is, in other words: Is decussation *total* or is it *partial*? I shall endeavor to recite arguments in proof that *all* the optic nerve fibres in the optic tract *do* decussate in the chiasma, and thus disprove the doctrine of semi-decussation taught in all our text-books.

We shall assume as granted the existence of the law of isolated conduction in reference to the fibres of the optic *tracts* and optic *nerves*, *i. e.*, that the nerve fibrils are multiple, and constitute an essential element in the mechanism of vision; that they have a real, continuous course from localities far behind those *usually* assigned, even from the cortex cerebri to their termination in the retina, or to be more exact, in the ganglion cell-layer of the retina. Morphologically, therefore, the optic nerve may be regarded as a part of the cortex cerebri, and the retina itself as an outpost of the brain, since a portion of its fibres attach themselves to a fasciculus of the *corona radiata*, which has its origin in the cortex.

The chiasma or optic commissure consists of the aggregate plexiform interlacement of the *optic nerve fibres* placed side by side, destitute of a fibrous sheath, the whole being covered in by the pia-mater. It is situated beneath the corpus callosum, with which it is in connection through the Lamina Cinerea, and through the medium of the former, it is in connection with the anterior, middle and part of the posterior lobes of the brain.

The texture of the several parts of which it is composed is soft, succulent and, therefore, readily compressible. It rests upon the olfactory process of the sphenoid bone, a hard, unyielding body presenting, conspicuously, an elevation in reference to its surroundings. The chiasma thus situated, is to some degree *normally* pressed upon by the corpus callosum and also by the parts which it in turn supports above. It is bounded in front by the Lamina Cinerea, which forms the anterior part of the inferior boundary of the third ventricle; at either lateral angle, by the gray matter of the substantia perforata anterior, corresponding to the under-surface of the corpus striatum; behind by the Tubera Cinerea, which forms a part of the floor of the third ventricle; here are also situated the Pituitary Bodies, the posterior lobes of which contain a cavity; which, through the medium of the Infundibulum communicates with the third ventricle; also, the Corpora

Albicantia and the Substantia Perforata posterior, which forms the posterior part of the floor of the third ventricle, and corresponds to the under surface of the Optic Thalami.

The anterior perforated space is perforated by numerous orifices for the transmission of small vessels to the Corpus Striatum. These orifices, through which they pass, are in size three times as large as the vessels themselves, and therefore afford but slight support to them. These vessels are derived from the anterior and middle cerebral arteries of the "Circle of Willis." The posterior perforated space is perforated in like manner for the passage of blood vessels to the Optic Thalami; these are derived from the posterior cerebral arteries.

The relatively large size of the Chiasma, its peculiar and exceptional position render it eminently obnoxious to variable degrees of pressure in consequence of changed conditions of the numerous and diverse cerebral factors by which it is surrounded. In addition, "Michel has devoted much attention to the upper surface of the commissure, and its relation to a layer of gray matter over it containing a recessus or cavity communicating with the third ventricle in the middle line and the lateral ventricle at the sides, in such a way that fluid injected into one lateral ventricle would distend this cavity, and so press on the commissure. The communication of this recessus with the third ventricle is of great importance pathologically, as in this way the front, lateral or posterior parts of the commissure may be pressed on."

I am the more desirous of giving special emphasis to the form and situation of this body and of its relations to the several parts immediately adjacent, since, on the theory of *total decussation*, *upon its four angles and their vicinity* must be impressed the proximate causes of all hemiopic symptoms. The region within which these causes are to be found, is, therefore, very limited; while on the theory of *semi-decussation*, the causes, being the *same*, may be sought at any point in the course of the optic tract, between

the Optic Chiasm and its origin in the cerebral ganglia, and in its more remote points of origin in the gray substance of the hemispheres.

*Pressure*, either directly or in its results, inducing nutritional changes, as will be shown, at length, in the sequel is the *occasion*, probably, of all forms of hemiopia from intra-cranial causes, whatever may be the nature of the cause by which the pressure is exerted. If this be applied at the anterior angle of the Chiasma, temporal hemiopia will result; the central portions only of the entire ordinary visual field being illuminated; for the optic nerve fibres supplying the nasal halves of the two retinæ are compressed, and their sensibility destroyed, or conductivity interfered with.

If it be applied at the right lateral angle, the right halves of each retina will be incapacitated, and, consequently, vision in the right visual fields alone is possible; if, on the other hand, it be applied at the left lateral angle, vision in the left visual fields alone remains. Again, if the pressure be applied at the posterior angle, the optic nerve fibres destined to the *outer* halves of both retinæ being compressed, their faculty power of conduction destroyed, and these portions of the retinæ incapacitated, vision in the outer fields alone remain, constituting nasal hemiopia; a form of hemiopia inexplicable on anatomical grounds on the theory of semi-decussation.

Now, this is a simple and very intelligible presentation of the entire subject of the mechanism of causation, and an unequivocal guide to the solution of all the forms of hemiopia.

The array of authority in support of semi-decussation, the theory now generally prevalent is truly formidable, viz.: *Newton, Vater, Wollaston, Mueller, Graefe, Jackson, Hirschberg, Knapp, Wilson, Gudden, Reich, Schoen, Monk* and others; but names, however distinguished, avail but little, if their doctrines, subjected to the crucial test of later discoveries, are found to have been predicated upon the sandy foundation of mere hypothesis. But yet, to

illustrate the doctrine of total decussation, we are able to record a galaxy of worthy names, viz: *Biesiadecki, Mandelstamm, Michel, Brown-Sequard, Pawlowsky, Cohn, Illing, Bastian* and others, whose names, though of less repute in the republic of medical science, will ever receive the merited honor of bringing to naught the hypothesis and teachings of their predecessors; for *their* doctrines are founded upon the everlasting rock of anatomical demonstration.

I shall now offer reasons why the theory of semi-decussation cannot be sustained; and

First. It is founded upon an hypothesis.—I have not been able to satisfy myself as to the opinions and teachings of the *earlier* anatomist respecting the subject of decussation, but upon consulting the writings of Hieronymus Fabricius, a distinguished anatomist of the seventeenth century, I find this statement, viz: “The optic tracts approach each other and *appear* to decussate at the chiasma, but they do *not* thus decussate; the right optic tract after this approximation leaves its fellow, and becomes the optic nerve and proceeds to the right eye, and left optic tract in like manner to the left eye.” It was, therefore, his opinion that no decussation whatever took place, each eye being supplied exclusively by optic nerve fibres from its own side. This declaration, we know, is widely at variance with the observations of later anatomists. Vesalius, however, who flourished a century earlier, records an anomalous case, in which “there was *no* junction of the optic nerves, and the sight was never double,” nor were other symptoms mentioned by him; and an instance of congenital absence of the optic commissure is now preserved in the museum of Westminster Hospital, London. These are certainly very exceptional cases.

Whatever may have been the accepted doctrine prior to his time, Sir Isaac Newton was the first, who, in the year 1704, from physiological reasons, as he conceived, advanced the possibility of a partial decussation of the optic nerve fibres to account for the phenomena of

Hemiopia. It was with him but an *hypothesis*, a mere conjecture. He *himself* may not have been convinced of its reality, but on this assumption, certain observed phenomena obtained a more ready solution than on any other hitherto suggested. Perchance he only *designed* this as a mere hypothesis, after the manner of astronomers, who in their effort to account for perturbations observed in the revolutions of certain planets, assume the existence of an intermediate planet hitherto undiscovered, and then pursuing a course of reasoning and calculation upon this assumption, determine whether the hypothetic planet, if it actually did exist, is capable of producing the phenomena observed. It was thus "Bruno conjectured the fundamental fact of the nebular origin of the heavenly spheres; Kant reasoned out its foundation idea, and LaPlace developed it."

Twenty years after the promulgation of this hypothesis, three cases of Hemiopia by *Vater*, in a dissertation, were explained on the theory of semi-decussation, thus lending it additional confirmation. A century later the same theory was adopted by Dr. Wollaston, of London, to account for hemiopic symptoms, of which he thrice was the subject.

Second. The theory of semi-decussation is disproved by physiological experiment.—It has been ascertained that section of *one* optic tract in living animals gives rise, *not* to bilateral hemiopia, as would result if decussation was partial, but to amaurosis of *one eye only*, and *that* of the opposite side; also that section longitudinally through the chiasma in the median line, causes *complete* amaurosis; which is in harmony with the doctrine of total decussation, since all the fibres of both tracts would thus be divided: while on the theory of semi-decussation temporal hemiopia would result. Flourens ascertained that destruction of either *Corpus Quadrigeminum* was followed by loss of vision in the eye of the *opposite* side. If both these are destroyed, blindness, double and complete, is the result. In like manner it has been ascertained that destruction of one angular gyrus, where Ferrier

located the origin of the optic nerve, produces temporary blindness in the opposite eye; and when the angular gyri of both hemispheres are destroyed, blindness of both eyes is produced and that permanent.

Third. The theory of semi-decussation is disproved by clinical experience.—In cases of unioocular neuritis, from a cerebral tumor, recorded by Dr. H. Jackson, the neuritis was on the side *opposite* to that of the tumor. Wundach reports a case in which the *left* eye had, for a long time, been blind from detachment of the retina; he found, on examination after death, atrophy of the *left* optic nerve, and also of the *right* optic tract. Beer relates a case of disease of the substance of the *left* hemisphere which had resulted in blindness of the *right* eye *only*, from intra-cranial disease of the left side. It was found to be occasioned from the effects of a vascular cyst containing two ounces of fluid in the substance of the posterior part of the *left* hemisphere. Magendie also records a case in which the *right* eye having been for a long time lost, the optic *nerve* was atrophied throughout its entire length to the optic commissure, and also the *left* optic tract to its visible source of origin, that condition usually found consequent upon loss of function. Irrefragible evidence of our position is furnished by the case of Professor De Morgan, a distinguished mathematician, examined by Dr. Bastian, and by him reported: “The patient was blind in the *right* eye almost from birth; the corresponding *optic nerve*, upon section, was found to be atrophied, and, likewise, the *left* optic tract; while the optic tract of the *same* side presented a healthy appearance.” And, akin to this case, and rendering accumulative proof, is that of a dog examined by Michel. This animal had been affected with congenital malformation of the eye of the right side; the *right* optic *nerve* and the *left* optic *tract* were found, on section, to be atrophied. In all these cases, on the theory of semi-decussation, one optic tract alone having suffered lesion, there should have resulted bilateral hemiopia, since each tract supplies corresponding portions of both retinae.

Fourth. The theory of semi-decussation is disproved by the teachings of comparative anatomy.—It is admitted even by the advocates of partial decussation, that in birds, the bat, in the osseous fishes—the cod, halibut and sturgeon—in rabbits and dogs, the decussation is *total*. The same condition has been found in all vertebrates in which decussation has been demonstrated; and we are authorized to assert, on the authority of Biesiadecki, that the same obtains in *all* vertebrates, including man, one scheme of conformation everywhere prevailing. And why should there be found an exception in man? Is it not possible? Some one may inquire. Yes, it is *possible*, and nature is competent to inaugurate this anomaly, but she is not fickle or capricious; nor does she delight in departures from certain well-defined models in creation, now adopting one scheme and now another. She works according to simple, general and inflexible laws, and, when uninfluenced by extraneous causes, produces uniformity of results. The autocracy of general law everywhere prevails, and wherever anomalies or monstrosities occur, they are due to some mechanical impediments or interference in the process of development, which were insuperable.

Fifth. The theory of semi-decussation of the optic nerve fibres in man is disproved, finally, by the anatomy of the optic commissure itself.—This affords the coronal and *ne plus ultra* testimony, and must forever disarm argument, dispel doubt and silence conjecture. Hypothesis on this subject, has dominated the medical world for a century and a-half. But hypothesis and theories thereon constructed, that will not triumphantly endure the ordeal of demonstration must fall, and speculative physiology must ever yield to the revelations of anatomy. Biesiadecki appears! And he alone enjoys the honor of first grasping this fallacy and given to *it* a successful refutation, though so long maintained and embalmed in all works on descriptive anatomy. He was so fortunate as to be able to pursue every single fibre of one

optic tract through the chiasma to the optic nerve of the opposite side, by the separation of the fibres of the chiasma, and thus succeeded in demonstrating total decussation. Michel and Mandelstamm, simultaneously and independently of each other, arrived at the same result. They never found the fibres of one tract *bending round* to the nerve of its own side, but they all pass to the optic nerve of the opposite side. Michel states: "the optic commissure in man is made up of the fibres of *both* nerves arranged in a kind of *basket-work*, whose meshes form more or less irregular squares." He thus renders unequivocal corroboration to the anatomical demonstration of Biesiadecki. It was venial in the dim twilight of medical science of Newton's time, that this hypothesis should have been proposed and taught, awaiting the advent of better and truer things; but now, in the full blaze of its meridian splendor, hypothesis gracefully yields to demonstration; anatomy, confirming the substitution, imparts fitting correction to the printed page, and time, the great arbiter of all things, transmits the record of the present to the judgment, revision and perfection of the future.

[Other aspects of this subject will occupy our attention in the next number.]

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The forms of Hemiopia, with few exceptions, may be embraced under one of the following, viz.: 1st, Bilateral—*(a)* right-sided, *(b)* left-sided; 2d, Temporal; 3d, Nasal. All hemiopic phenomena are readily explained on the theory of *total* decussation. It cannot be denied that *most* of them can be accounted for on the theory of partial decussation; but those must always be excepted which are due to *nasal* hemiopia. In respect to these, when occasioned by cerebral causes, V. Graefe, though favoring the hypothesis promulgated by Newton and re-affirmed by Müller, frankly confessed himself incapable of giving an anatomical explanation.

That which I have attempted to prove may be formulated as follows, viz:

1st. Diseases involving the optic tract of *one* side will produce total blindness of the eye on the opposite side; and not bilateral hemiopia.

2d. Diseases affecting either lateral angle of the chiasma, involving both the optic nerve fibres entering and also those leaving it, will produce bilateral hemiopia; and not *nasal* hemiopia in *one* eye.

3d. Diseases affecting the posterior angle, in the median line, involving the optic nerve fibres of *both* tracts that enter the chiasma, will affect the outer half of each retina and produce *nasal* hemiopia; a form utterly inexplicable on the theory of partial decussation, and

4th. Disease in front of the commissure will affect the inner halves of each retina, and produce temporal hemiopia; the phenomena of which are alike explicable on either theory.

Mandelstamm epitomizes the entire subject in the brief, terse, oracular declaration "no facts yet contradict the doctrine of total decussation; but anatomical investigations, physiological experiments and clinical experience harmonize to confirm it."

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